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Art. XV.—*On some Fragments of* Áryabhaṭṭa. By Dr. H. Kern.

[*Read 16th March*, 1863.]

There are few names in the history of Indian science which have acquired a celebrity equalling that of Áryabhaṭṭa. He is—to use the words of Colebrooke—"the earliest author known to have treated of Algebra among the Hindus, and likely to be, if not the inventor, the improver, of that analysis; by whom, too, it was pushed nearly to the whole degree of excellence which it is found to have attained among them." But, notwithstanding the renown of the Indian algebraist and astronomer, not only among his countrymen, but also among the Arabian scholars, his works seemed to be lost. Neither was Colebrooke successful, nor was Davis more so, in their endeavours to find any work of his. What was known about his doctrine, which in many points deviated from the prevailing opinions among Indian astronomers, was derived from quotations occurring in various mathematical and astronomical writings. Now, it is deserving of notice, that in Southern India there are copies extant of works that most unequivocally lay claim to being the genuine productions of Áryabhaṭṭa. The late Mr. Whish knew an Áryabhaṭṭíyam, a treatise on arithmetic and mathematics, to which I shall have to revert in the course of this paper. Prof. Lassen says, in his *Indische Alterthumskunde*,[1] that he has received from Southern India copies of two works ascribed to Áryabhaṭṭa, viz., of the above-mentioned Áryabhaṭṭíyam and of the Daṣagítaka-sútra. In an article on the Árya-siddhánta in the 6th volume of the Journal of the American Oriental Society, Dr. Fitz-Edward Hall has verified an Árya-siddhánta, of which he possessed two imperfect copies, by extracts occurring in the writings of various commentators. The conclusion he arrives at is, that there were two authors of the name. If the same course were adopted in regard to all the works ascribed to Áryabhaṭṭa, or to an Áryabhaṭṭa, if their contents were compared with the numerous fragments scattered in different works, chiefly commentaries, one might indulge the hope that the question of the authorship of Áryabhaṭṭa would be settled in a satisfactory manner.

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[1] *Ind. Alterth.*, 2nd vol., p. 1136. Prof. Lassen concludes, from the somewhat equivocal words of Reinaud, *Mémoire sur l'Inde*, pp. 321 and 322, that the Áryabhaṭṭíyam is spoken of by Albírúní. So far as I can see, Albírúní intimates only that the Indian astronomical systems (*méthodes*) could be reduced to three, the Sindhind, the Áryabhaṭṭa, and the Arkand. It is an inference of Reinaud that the system called Áryabhaṭṭa is identical with the Áryabhaṭṭíyam, which, according to Whish, is not a treatise on astronomy, but on arithmetic and mathematics.

This is a task, however, I cannot assume at present; and I propose only to contribute a small share towards solving the question by giving the following extracts. All of them are taken from the commentary of Bhaṭṭa Utpala on the Váráhí Sanhitá, or Bṛihat-Sanhitá, of Varáha-mihira. According to the list of astronomical writers furnished by the astronomers of Ujjayiní to Dr. Hunter, and published by Colebrooke (Algebra, Note E), the commentator flourished about the Ṣáka-year 890 (A.D. 968-69); and, agreeably to this statement, it is said, at the end of the commentary, that it was finished in the Ṣáka-year 888, or A.D. 967.[1]

I am sorry to say that the copies of Utpala's commentary are in such a condition that I have often been obliged to recur to conjectures, most of them, however, being obvious. The uncertainty about the true reading materially affects the translation; and the want of any explanation on the part of Utpala does so in a no less degree. At the same time, I am of opinion, that the greater or less degree of correctness of the extracts by no means renders them less important for the purpose of comparing them with the complete works ascribed to the renowned Indian mathematician and astronomer.

I shall begin with the following extract, which is to be found in the commentary on the second chapter of the Váráhí Sanhitá:[2]

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[1] The date in full is given in Utpala's own words:

फाल्गुनस्य द्वितीयायामसितायां गुरोर्दिने ।
वस्वष्टाष्टमिते शाके कृतेयं विवृतिर्मया ॥

"On the second lunar day of the dark half of the month Phálguna, on a Thursday, in the Ṣáka-year 888, I finished this commentary."

[2] One of the MSS. belonged formerly to Colebrooke: for convenience sake, I shall call it B, and the other A. The fragment is introduced, in B, by the words तथा चार्यभट्टः, in A by तथा चाचार्यभट्टः. The various readings, mere blunders being omitted, are: B सर्वतो प्यंते for सर्वतो वृत्तः.—B सर्वसंघैः.—A प्रभाकरो, B प्रभास्वरे.—A मकरो for नरको.

वृत्तभपञ्जरमध्ये कक्ष्यापरिवेष्टितः खमध्यगतः ।
मृज्जलशिखिवायुमयो भूगोलः सर्वतो वृत्तः ॥
यद्वत्कदम्बपुष्पग्रन्थिः प्रचितः समन्ततः कुसुमैः ।
तद्वद्धि सर्वसत्त्वैर्जलजैः स्थलजैश्च भूगोलः ॥
मेरुर्योजनमात्रः प्रभास्वरो हिमवता परिक्षिप्तः ।
नन्दनवनस्य मध्ये रत्नमयः सर्वतो वृत्तः ॥
स्वर्मेरू स्थलमध्ये नरको वडवामुखं च जलमध्ये ।
असुरसुरा मन्यन्ते परस्परमधःस्थितान्नियतम् ॥

"The terrestrial globe, a compound of earth, water, fire, and air, entirely round, encompassed by a girdle [*the equator*], stands in the air, in the centre of the stellar sphere. Like as the ball formed by the blossoms of the Nauclea Kadamba is on every side beset with flowerets, so is the earth-globe with all creatures terrestrial and aquatic. Mount Meru, measuring only a *yojana*, being wholly round, and consisting of gems, spreading lustre, and surrounded by the snowy mountain, is in the midst of Paradise.[1] Heaven and Mount Meru are in the midst of the land; hell and the Vaḍavámukha are in the midst of the waters. The gods and the demons, of necessity, deem each other to be undermost."

The general features of this geographical system agree with that of the Súrya-siddhánta (chapter 12), and other astronomical works. By hell, *naraka*, is intended the abode of the demons; and Vaḍavámukha, denoting, in popular belief, as well the submarine fire as a kind of Charybdis and abyss, is here, as it will appear more clearly from another passage of Áryabhaṭṭa, the supposed abode of the dead. We find here, about the division of our planet into land and water, nearly the same notion that prevailed, not only in other text-books of Indian astronomy, but also with Greek geographers, as Eratosthenes and Strabo, namely, that the northern hemisphere only is a continent and inhabited, and that the southern half consists of water, and is uninhabitable, at least for men. A peculiar feature of this piece of Áryabhaṭṭa's geographical system, which distinguishes it from the prevailing opinion of the Hindus, is his acknowledging only four, not five, elements. To account for this peculiarity by assuming him to have adopted this doctrine from the Bauddhas and Jainas seems objectionable, because these sects are notorious for their preposterous ideas about the heavenly bodies,[1] quite different from those of Áryabhaṭṭa. I would rather suggest that he borrowed this idea from the Greeks. However, it is but fair to say that he could *not* have borrowed the idea from an ancient work of reputed Greek origin, viz., the Pauliṣa-siddhánta, the author of which was Puliṣa, or, as Albírúní styles him, Paulus the Greek. For we know, accidentally, from a quotation by Bhaṭṭa Utpala, that the Pauliṣa-siddhánta acknowledges five elements. It will not be out of place to give the very words:[2]—

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[1] The word Nandanavana, rendered here by Paradise, is the well-known garden of India. It is also called Nandanadyána in the Kathá-sarit-ságara, *taranga* 28, vs. 52 (edition of Brockhaus in the *Abhandlungen für die Kunde des Morgenlandes*, 1862).

वृत्ता चक्रवद्‌वनिस्तमस्य पारे विनिर्मिता धात्रा ।
पञ्चमहाभूतमयी तन्मे मेरुरमराणाम् ॥

"The earth is round like a wheel (or disk), produced by the Creator at the end of darkness. It consists of five elements. In the midst of it is the Meru of the gods."

It will be seen at once, that the shape of the earth being compared to a wheel or disk implies a much lower degree of geographical science than is met with in any Indian book on scientific astronomy.

To revert to Áryabhaṭṭa, I subjoin the original of a passage already noticed and translated by Colebrooke in his Algebra, Note I:[3]—

मेषादेः कन्यान्तं सममुदगपमण्डलार्धमुपयातम् ।
तौल्यादेर्मीनान्तं शेषार्धं दक्षिणेनैव ॥

"An equal half of the ecliptic, from the beginning of Aries to the end of Virgo, is situated in the north; the other half, from the beginning of Libra to the end of Pisces, is in the south."

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[1] See Colebrooke, *On the sect of the Jainas*, and As. Res., xii, p. 228.

[2] They are to be found in Cod. A, fol. 29, in B, fol. 33. The latter MS. has तमस्पारे विनिर्मुक्ता.

[3] Here both copies concur in reading तथा चाचार्यभट्टः, intending, very likely, चाचार्यार्यभट्टः.—A सममुदगयनं म°, B समुदयगपम°.

The following two passages bear upon the relative distance of the planets, including the sun and moon, from the earth, the supposed centre of the celestial sphere, and upon the relative dimensions of the planetary orbits:—

भानामधः शनैश्चरबृहस्पतिकुजार्कशुक्रबुधचन्द्राः ।
एषामधश्च भूमिर्मेषीभूता खमध्यस्था ॥

"Below the fixed stars are, successively, Saturn, Jupiter, Mars, the Sun, Venus, Mercury, and the Moon; below all these is the Earth, being in the midst of the ether."[1]

Concerning the relative dimensions of the orbits, Áryabhaṭṭa has taught thus:—

मण्डलमल्पमधस्तात्कालेनाल्पेन पूरयति चन्द्रः ।
उपरिष्टात्सर्वेषां महच्च महता शनैश्चारी ॥
अल्पे हि मण्डलेऽल्पा महति महान्तश्च राशयो ज्ञेयाः ।
अंशाः कलास्तथैवं विभागतुल्याः स्वकक्षासु ॥

"The Moon, being undermost, completes a small circle in a short time; and Saturn, being uppermost, a large circle in a long time. For upon a small circle the signs are small, whereas they are great upon a large circle; so, too, the degrees and minutes are divided proportionately to the respective orbits."

Áryabhaṭṭa, for aught we know, was the first, and remained almost the sole, astronomer among his countrymen, who affirmed the daily revolution of the Earth on its own axis. His words, as quoted by Utpala,[2] differ from those cited by Prithúdakaswámin, the commentator of Brahmagupta (As. Res., xii, p. 227); but it is superfluous to remark that the same author had more than one opportunity, either in the same work or in some other, to repeat his assertion.

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[1] The word *meshibhútá* is omitted in the translation, since it is devoid of meaning in this connexion. I surmise that we ought to read *medhibhútá*, *medhi* being "a post fixed in the centre of a threshing-floor or barn, to which the cattle are attached, as they turn round it to tread out the corn."—*Wilson.*

[2] A has आचार्यार्यभट्टेन, B आचार्यभट्टेन.

अनुलोमगतिर्नौस्थः पश्यत्यचलं विलोमगं यद्वत् ।
अचलानि भानि तद्वत्समपश्चिमगानि लङ्कायाम् ॥

"As a person in a vessel, while moving forwards, sees an immoveable object moving backwards, in the same manner do the stars, however immoveable, seem to move (daily); at Lanká (*i.e.*, at a situation of no geographical latitude) they go straight to the west (*i.e.*, in a line that cuts the horizon at right angles, or, what is the same, parallel to the prime vertical at Lanká)."

The theory of the immobility of the fixed stars is not approved of by Bhaṭṭa Utpala, who endeavours, consequently, to refute it, partly by reasonings of his own, partly by invoking other authorities. One of his arguments is based upon the supposition that birds, after having soared to the sky, would be unable to find again their nests, यद्येवं (if the Earth moved) श्येनाद्या न खात्पुनः स्वनिलयमुपेयुः Further, he appeals to the Pauliṣa-siddhánta, which taught:[1]—

तस्योपरि ध्रुवाख्ये तद्बद्धं पवनरश्मिभिश्चक्रम् ।
पवनाक्षिप्तं भानामुदयास्तमयं परिभ्रमति ॥

"To its (the celestial sphere's?) so-called upper pole this wheel is fastened with cords of air; the (points of) rising and setting of the stars propelled by the wind are always revolving."

This is another instance of the inferior quality of the science expounded by Puliṣa. Another authority appealed to by Utpala is the Brahma-siddhánta, an extract from which is here subjoined:

ध्रुवयोर्बद्धं सव्यगममराणां क्षितिजसंस्थमुडुचक्रम् ।
अपसव्यगमसुराणां भ्रमति प्रवहानिलाक्षिप्तम् ॥
अन्यत्र सर्वतो दिशमुन्नमति भपञ्जरो ध्रुवो नमति ।
लङ्कायामुडुचक्रं पूर्वापरगं ध्रुवो क्षितिजे ॥

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[1] The reading is conjectural, A exhibiting ध्रुवे, B भ्रुवाख्ये. As to the general meaning there can be no doubt.

"The circle of asterisms (the ecliptic) connected with the two poles revolves, being propelled by the provector wind; to the gods (being at the north pole) it is in the horizon, and moves from left to right,[1] but, to the demons, from right to left. Everywhere else the sphere is elevated, and the pole is depressed. For Lanká (*i.e.*, for a place of no latitude), however, the circle of asterisms goes from the east point of the horizon to the west point, and there the pole is in the horizon."

Utpala might have selected more unobjectionable passages than this, which commits the unwarrantable inaccuracy of confounding the ecliptic with the equator. A third authority opposed to Áryabhaṭṭa—and it is not a little surprising to learn this—is Áryabhaṭṭa himself. For Utpala cites from him as follows:—

उदयास्तमयनिमित्तं नित्यं प्रवहेण वायुनाक्षिप्तः ।
लङ्कासमपश्चिमगो भमण्डलः सग्रहो भ्रमति ॥

"The cause of the rising and setting is, that the circle of asterisms, with the planets, being always propelled by the provector wind, moves straight to the west."

This passage may have been one of those on which Brahmagupta founded his charge of inconsistency against his renowned predecessor (see Colebr., Algebra, Note G, and As. Res., xii, p. 213). But, without knowing more of the context, we dare not assert Áryabhaṭṭa to have been really inconsistent: the foregoing stanza does not prove what Utpala supposes it to prove. Nor is it necessary to assume that this stanza is from another work of the same author. It is by no means improbable that the author simply intended, here, to report the opinion of others, or to give a description how the luminaries appear to move. It is deserving of remark that Utpala, who could have strengthened his position by pointing out the inconsistency, does nothing of the kind. This looks as if he were himself aware of his quotation's being inconclusive. I pass from the commentary on the second chapter of the Váráhí Sanhitá to that on the sixteenth, vs. 6. The fragment to be found there has been alluded to by Dr. Fitz-Edward Hall, in the Journal of the Am. Or. Soc., Vol. VI, p. 559.

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[1] For the sense of the terms *savyaga* and *apasavyaga*, see Súrya-siddhánta, ch. 12, vs. 55, and the valuable translation of it by the Rev. Mr. Burgess and Prof. Whitney.

देवाः पश्यन्ति भगोलार्धमुदग्मेरुसंस्थिताः सव्यम् ।
अपसव्यगं तं चार्धं दक्षिणवडवामुखे प्रेताः ॥[1]

"The gods dwelling on Mount Meru, in the north, see half of the asterisms going from left to right; the same half is seen by the dead in Vaḍavámukha, in the south, moving from right to left."

As to Meru and Vaḍavámukha, I refer to the extract near the beginning of this paper.

The last extract I have to offer is, in more than one respect, of high importance. Áryabhaṭṭa, as has been mentioned by Davis, in the As. Res., iii, p. 215, and afterwards by Colebrooke, in the As. Res., xii, p. 244, and Algebra, Note 1, stated the revolutions of Jupiter in a Maháyuga to be 364,224. The original is given by Utpala in his comment on ch. 8, vs. 1, of the Váráhí Sanhitá:[2]

गुरुभगणा राशिगुणा आश्वयुजाद्या गुरोरब्दाः ॥
गुरुभगणानां संख्या जिनयमवेदर्तुहव्यभुजतुल्या ॥

"The revolutions of Jupiter, multiplied by the number of the signs (12), are the years of Jupiter, called Áṣwayuja, &c.; his revolutions are equal to the number of the Jinas, a couple, the Vedas, the seasons, the fires (*i.e.*, 364,224)."

There are, in this stanza, two circumstances that call for particular attention. In the first place, it is clear that Áryabhaṭṭa most distinctly states the first of the twelve years in the revolution of Jupiter to be Áṣwayuja, whereas, generally, up to the present day, the first year is called Kárttika. If we were sure that this fact implied another, viz., that Áryabhaṭṭa considered the lunar mansion Aṣwiní to be the first of the series, instead of Kṛittiká, we should have one datum more for determining approximately his age. Before pronouncing upon the question, we have to bear in mind that the rule, according to which the twelve years of Jupiter received their names, is not uniform. Varáha-mihira[1] prescribes, that "the name of the year of Jupiter is determined from the asterism with which Jupiter rises heliacally, and that the years follow in the same order with the months." Other astronomers or astrologers of far more ancient date, as Garga, Káṣyapa, and Ṛishiputra, give rules of the same purport. In order to avoid needless prolixity, I refer to the copious treatment of this subject by Davis, in the third volume of the As. Res., pp. 217, sqq. It is obvious that the rule laid down in Varáha-mihira, or rather repeated by him, was framed at a time when the series of asterisms was reckoned from Kṛittiká, and not yet from Aṣwiní. It is, further, obvious that the same rule could not be followed after Aṣwiní's beginning the ecliptic, unless the first year changed its name. Now, we are directed by the Súrya-siddhánta (ch. 14, vs. 17) to determine the name of a year of Jupiter from that asterism in which the Sun and Moon will be in conjunction at the end of the month in which the heliacal rising and setting take place. The first month being called Vaiṣákha,—so-called because originally full moon occurred in the asterism Viṣákhá,—it follows that the conjunction of the Sun and Moon, at the end of this month, will fall in Kṛittiká; and, agreeably to the rule, the first year of Jupiter is to receive the name of Kárttika. In this manner the order of the years is preserved; but it could be so only if the Súrya-siddhánta, which considers Aṣwiní to be the first asterism, changed the rule of Varáha-mihira, or rather of his predecessors. Very likely the rule of the Súrya-siddhánta is an innovation by which it was designed to find a means of leaving unaltered the traditional order of the years. It is pretty sure, that Áryabhaṭṭa, whether the first asterism with him was Kṛittiká or Aṣwiní, could not have determined the names of the years in the same manner with the Súrya-siddhánta. For, on the former supposition, the first year would have been called Márgaṣírsha; in the latter, it would receive the name of Kárttika. Unfortunately, we cannot assert so confidently whether he did or did not make use of the rule with Varáha-mihira. If he really did, then the necessary consequence would be, that in his time the first of the series of asterisms *was* Aṣwiní. But it will be permitted to affirm that the fragment quoted affords no sufficient data for deciding this question satisfactorily.

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[1] Both MSS. have भूगोलार्द्धं, which here is devoid of sense, and moreover disturbs the metre. Further, A has उत्तरमेरु, B उदगमेरु. —B तच्चार्द्धं, A तदर्द्धं.

[2] B has संज्ञा for संख्या, and वेदांग. The latter is unobjectionable, provided it be taken for two words, not for a compound.—A निनयनवेदर्तु.—Both have तुल्याः, and have added, in numerals, ३६४२२४.

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[1] Var. Sanh., ch. 8, vs. 1.

We are in a more favourable position as to the second fact worthy of notice, which I alluded to. For it may be shown that the way in which Áryabhaṭṭa gives the number of Jupiter's revolutions implies that he has made use of our arithmetical notation. This fact, although by no means surprising of itself, has acquired importance since the discovery, by Whish,[1] of an alphabetical notation in the Aryabhaṭṭíyam. This discovery has induced Prof. Brockhaus[2] to assert that Áryabhaṭṭa was unacquainted with the decimal notation; and with him agrees Reinaud, to whom we are indebted for an interesting *Mémoire sur l'Inde.* The latter scholar expresses his opinion in the following words:[3] "Apparemment, le procédé employé par Aryabhatta (viz., *the alphabetical notation*) était tombé en désuétude au temps d'Albyrouny. Néanmoins, les traités scientifiques composés par Brahmagupta, au 7° siècle de notre ère, et par les écrivains postérieurs, ne supposent pas, en général, l'usage des chiffres; les nombres sont exprimés par des mots susceptibles d'être rattachés à une qualité quelconque." Now, it is very true, as well as generally known, that, in Sanskrit works, numbers may be denoted by other words than the usual names of the numerals. This, however, has nothing whatever to do with the question of a particular notation, but is a matter merely of prosody. It is quite immaterial whether one chooses to say *tri* or *agni*, as, in English, *twenty* or a *score;* the essential point is to know whether the name of a unit, whatever the sound of that name may be, may occur at another place than the first right-hand place. When it is unquestionable—and so it is in the above-cited stanza—that, for instance, the sixth numeral from the right, denoted by a word for *three*, has the value of three hundred thousand, it is clear that the notation must have been a decimal one. Every passage in any Sanskrit book where we meet with the same method of expressing the numerals by the names of things, considered to present themselves in a certain quantity, tells us that it originated at a time when the decimal notation was known in India, with this restriction, that the numeral must consist of at least two figures. The fragment quoted shows, not only the views of Prof. Brockhaus and M. Reinaud to be inadmissible, but also, I believe, those of Prof. Lassen. This most distinguished scholar argues, from the existence of an inscription of the *Samvat*-year 380 or 323, which exhibits an alphabetical notation, that, in the time of Áryabhaṭṭa, the decimal system was not yet *fully* developed; although he rightly urges, on the other hand, that the discovery of an alphabetical notation does not involve an entire ignorance of the ciphers (see Ind. Alterth., 2nd vol., p. 1139, and Thomas, in his edition of Prinsep's Indian Antiquities, 2nd vol., pp. 80–84). Assuming the *Samvat*-year to mean the year of the Vikramáditya-era, it remains still to be proved, first, that Áryabhaṭṭa lived before or about 380 or 323 of the Vikramáditya-era, and, secondly, that the use of a certain notation in *one* monument involves the general currency of the same notation, for every use, throughout the whole of India.

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[1] *Transactions of the Lit. Soc. of Madras*, 1827.

[2] *Zeitschrift für die Kunde des Morgenlandes*, vol. iv, p. 81.

[3] *Mémoire sur l'Inde*, p. 299.

Thus we may safely conclude, I think, that the great algebraist has made use, in his calculations, of the system handed down to us by the Arabians, and to these by the Hindus. To the unpractical alphabetical notation no regard has been paid, even by those Indian mathematicians who derived their science mainly from the works of the reputed founder of algebra. Whish, *l. c.*, p. 56, tells us: "I am not, indeed, aware that it has since been in use among mathematicians, never having observed it in their works. It must, however, have been understood by them; for the three books, Līlāvatī, Laghu-Bhāskarīyam, and Mahā-Bhāskarīyam, of Bhāskara-āchārya are founded upon the principles of the Āryabhatīyam; the Līlāvatī, in particular, is composed from the second chapter of the work."

If Bháskara nowhere mentions the alphabetical notation, Albírúní decidedly knew nothing of it (see *Mémoire sur l'Inde*, p. 299); which would be rather strange, if, by the third of the three astronomical systems, Siṅdhind, Arkand, and Áryabhaṭṭa, the Áryabhaṭṭíyam really was intended. But I have already stated my grounds for not believing this work to be identical with the system of Áryabhaṭṭa.

The above fragments of Áryabhaṭṭa are not of a nature, at least to my idea, to afford new data for fixing his age. The last extract, exhibiting Áṣwayuja as the name of the first year in Jupiter's revolution, makes, indeed, the impression that he considered Aṣwiní to be the first asterism; but it is no more than an hypothesis, so long as it is not corroborated by other evidence. And it may be observed that, if the hypothesis, after further investigation, should prove to be true, it still does not admit of the inference that, in his time, the very beginning of Aṣwiní coincided with the vernal equinox. And every degree of difference in longitude involves a difference of about seventy years in the time of precession. Therefore I shall content myself with referring to the discussion of the subject by a scholar who with most profound and vast learning combined so much cautiousness and conscientiousness, —by Colebrooke. He has made out that Áryabhaṭṭa lived before Varáha-mihira, who, according to external evidence, lived in the 6th century of our era (Algebra, Notes I and K; cf. *Mémoire sur l'Inde*, p. 337). He was not aware of Varáha-mihira's distinctly mentioning Áryabhaṭṭa; and, certainly, neither in the Sanhitá, nor in the Bṛihad-Játaka, nor in the Laghu-Játaka, is the name to be met with. Nevertheless, I believe I have found a passage, quoted by Utpala, and perhaps taken from the Panchasiddhántiká, in which the name occurs. The passage itself must have been known to Colebrooke; but the MS. he possessed is so badly corrupted, that it seems to have escaped his notice that the passage was from Varáha-mihira. In order that others may judge for themselves, I subjoin the whole passage, which is a little long, but, for many reasons, curious.

Bhaṭṭa Utpala, after giving the rules for finding the lord of the day, month, year, &c., proceeds to intimate that learned authorities are at variance touching the commencement of the days of the week (and consequently about that of the creation); some reckoning from sunrise, others from midday, others from sunset, and others, again, from midnight.

दिनपतिर्होराधिपत्योराचार्याणां निश्चयो नास्ति। केषांचिदौदयिको वारपतिरन्येषां माध्याह्निकोऽन्येषामास्तमयिकोऽन्येषामार्धरात्रिक इति॥ तथा चाचार्यः॥[1]

"The lord of the day of the week begins, with some, at sunrise, with others at midday, with others again at sunset, with a fourth school at midnight. So says also the Ácharya." The title *ácharya*, by itself, invariably means, with Utpala, Varáha-mihira; and the following extract exhibits, in every respect, the famous astrologer's style, being defective in precision and clearness:—

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[1] B, the MS. formerly in the possession of Colebrooke, omits ऽन्येषामास्तमयिको, which may account for his knowing only three schools, instead of four. See Algebra, Dissert., p. viii. Cf., however, Davis, As. Res., ii, p. 261.

द्युगणाद्दिनवाराप्तिर्द्युगणोऽ पि हि देशकालसंबद्धः ।
लाटाचार्येणोक्तं यवनपुरेऽ र्धास्तगे सूर्ये ॥[1]
रव्युदये लङ्कायां सिंहाचार्येण दिनगणोऽ भिहितः ।
यवनानां निशि दशभिर्गतैर्मुहूर्तैश्च तद्ग्रहणात् ॥[2]
लङ्कार्धरात्रसमये दिनप्रवृत्तिं जगाद चार्यभटः ।
भूयः स एव चार्कोदयात्प्रवृत्याह लङ्कायाम् ॥[3]
देशान्तरसंशुद्धिं कृत्वा चेन्न घटते तथा तस्मिन् ।
कालस्यास्मिन्साम्यं तैरेवोक्तं यथाशास्त्रम् ॥[4]
मध्याह्नं भद्राश्वेष्वस्तमयं कुरुषु केतुमालायाम् ।
कुरुतेऽ र्धरात्रमुद्यन्भारतवर्षे युगपदर्कः ॥
उदयो यो लङ्कायां सोऽस्तमयः सवितुरेव सिद्धपुरे ।
मध्याह्नो यमकोट्यां रोमकविषयेऽ र्धरात्रः स्यात् ॥
अधिमासकोनरात्रग्रहदिनतिथिदिवसमेषचन्द्रार्काः ।
अयनर्तुत्वगतिनिशाः समं प्रवृत्ता युगस्यादौ ॥
अन्यद्रोमकविषयाद्देशान्तरमन्यदेव यवनपुरात् ।
लङ्कार्धरात्रसमयादन्यत्सूर्योदयाच्चैव ॥

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[1] A has बालाचार्येण.—B वास्तगे.

[2] B omits मुहूर्तै.—A तद्गुणाः.

[3] A चाचार्यभट्टः, which is wholly out of the question. The reading of B, चार्यभट्टः, however, is also against the metre; and therefore I venture to read चार्यभटः, a form not infrequent in MSS., and in favour of which might be urged the fact that the Arabian transcription sounds Arjabhar. A has भूयांस एव चार्कोदयात्प्रभृत्याहुर्लंकायां, B यूयः स एव.

[4] A तथास्मिन् । सम्यं तैरेवोक्तं, B तथा च तस्मिन् । कातस्यास्मिन् शाम्यां तेरेवोक्तं.

सूर्यस्यार्धास्तमयात्प्रतिविषयं यदि दिनाधिपं ब्रूमः ।[1]
तत्रापि नाप्तवाक्यं न च युक्तिः काचिदप्यस्ति ॥
संध्या क्वचित्क्वचिदहः क्वचिन्निशा दिनपतिः क्वचित्कश्चित् ।
स्वल्पे स्वल्पे स्थाने व्याकुलमेवं दिनपतित्वम् ॥
होरावर्तोऽप्येवं यस्माद्धोरा दिनाधिपस्याद्या ।
तस्यापरिनिष्ठाने होराधिततिः कथं भवति ॥
अविचार्यैव प्रायो दिनवारे जनपदः प्रवृत्तोऽयम् ।
स्फुटतिथिविच्छेदसमं युक्तमिदं प्राहुराचार्याः ॥

"The day of the week is to be determined from the sum of days (viz., *from the creation*); the sum of days stands in connexion with situation and daytime. Láṭáchárya says that the days are to be reckoned from sunset in the city of the Yavanas. Sinháchárya states the sum of days (to begin) from sunrise at Lanká; and, in adopting this view, they must begin, with the Yavanas, at the time when ten *muhúrtas* of the night are past. Áryabhaṭa has affirmed that the day begins (*i.e.*, is considered by some to begin) at midnight at Lanká; but the same says, further, that the day commences (viz., according to his own opinion) from sunrise at Lanká. If, after taking into account the different longitude of a country, the result does not agree with the actuality in this country, yet the correspondence of time has been stated by the same authorities, on scientific principles, as follows:[2] The sun, while rising in India, at the same moment causes midday in the region of the Bhadráṣwas, sunset in that of the Kurus, midnight in Ketumálá. At the time of the sun's rising at Lanká, he is setting in the city of the Perfected; it is midday in Yamakoṭi, and midnight in Romaka-country. The intercalary months, the omitted lunar days, the days of the planets,[3] the lunar days, the days, the

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[1] A प्रतिवर्षं.

[2] The meaning of this obscure stanza seems to be, that there is no general rule for determining the commencement of the days of the week, this depending not only upon longitude, but also on the particular custom of a country. What, nevertheless, can be brought under scientific rules, is the correspondence of time. In other words, the rules are only *theoretic, yathásástram.*

[3] *U'narátra* and its synonym *Kinarátra* are wanting in the dictionaries. With the aid of etymology, we can make out that they mean the *night*, or nearly

Ram, the Moon, the Sun, the half-years, the seasons, the daily motion of the stars, the nights, start at (*i.e.*, must be reckoned from) the same moment in the commencement of the *yuga.* It is not the same if you count the longitude from Romaka-country and from Yavana-city; nor is it alike, if you begin from midnight at Lanká and from sunrise there. Neither do we, when determining from sunset the lord of the day for every situation, have trustworthy oral evidence, nor is there any means for inference. In one place it is twilight, elsewhere day, or night; in short, for every small distance there is a different lord of the day. So, ascertaining the lord of the day is an entangled question. The case stands the same for the return of the *horás*; for the *horá* is the first (hour) of the lord of the day: the latter not being fully ascertained, how can the lord of the *horá* be so? Generally, people here regulate their concerns on a day of the week, without considering such questions; the learned pronounce it to be right, when one takes the day to coincide with the limits of the apparent (*i.e.*, not the mean) lunar day."

Besides the name of Áryabhaṭṭa, or Áryabhaṭa, we are indebted to this quotation for one glimpse more into the geographical system of this astronomer and two others, Láṭácházrya and Sinhácházrya. It appears, from the words of the text, that these three agreed with each other. Comparing their opinions with the doctrine of the Súrya-siddhánta (ch. 12, vs. 37-40 and vs. 70), we find the same agreement. As Albírúní seems to give a somewhat different account, I will quote his words, as translated by M. Reinaud, and examine the weight to be attached to them:[1] "Il est dit dans le Paulisa-Siddhânta, composé par Paules le Grec, que la terre et la mer sont coupées par une ligne nommée Tilkascha,[2] c'est-à-dire, ligne sous laquelle il n'y a pas de latitude. Cette ligne répond à ce que nous appelons la ligne équinoxiale. Aux quatre points cardinaux sont quatre villes considérables, à savoir: Yama-Kota, à l'orient; Lanka, au midi; Romaka, à l'ouest; et Siddhapour, au

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so, by which the synodical lunar month of thirty *tithis* is *less* than thirty solar days. The number of *tithis* continually gaining upon that of the solar days, the difference will amount, in a little more than two months, to a whole *tithi*, which must be expunged. Therefore, *Únarátra* is rendered by *tithinaya*; it properly being the cause of the latter becoming necessary.—The days of the planets mean here, I think, the days of the week.

[1] *Mém. sur l'Inde*, p. 341.

[2] This word is certainly wrong. For ت one may read ن, and pronounce *nilaksha*, closely approaching the Sanskrit *niraksha*.

nord. Quand le soleil se lève sur la ligne qui va de Lanka à Merou, il est midi à Yama-Kota, minuit à Romaka et six heures du soir à Siddhapour." Reinaud proceeds thus: "Albyrouny ajoute que la même opinion avait été émise dans les Siddhântas composés par Aryabhatta, Vasishtha et Lat; mais il fait observer avec raison que, d'après les termes mêmes, il ne peut s'agir là des quatre points cardinaux, mais des quadrans de l'équateur." I cannot help mistrusting here the accuracy of the Arabian astronomer. The doctrine of the Pauliṣa-Siddhánta, absurd as it is, is consistent with the false assumption of the Earth's having the shape of a wheel or disk, as we have seen above. Therefore this Siddhánta must have intended really the four cardinal points. On the other hand, it is quite impossible that Áryabhaṭṭa, or any one else who supposed the Earth to be a globe, took the same view of the course of the Sun. The words of Varáha-mihira, as well as those of the Súrya-siddhánta, leave no doubt as to the author's meaning quadrants of the equator, and not the cardinal points. Moreover, we know that, according to Áryabhaṭṭa, at the north pole was situated Mount Meru, and, at the south pole, Hell. I fear that Albírúní has been too hasty in passing his criticisms.

I shall conclude with a remark suggested by the occurrence of the names of Romaka-country and Yavana-city.

It is intimated, that, in the country of the Yavanas, the time corresponding to sunrise at Lanká, that is, six o'clock in the morning, is ten *muhúrtas* in the night. It is not distinctly said at what time the night is to begin; but it can hardly be at another hour than six o'clock in the evening. Now, ten *muhúrtas* later gives two o'clock in the morning, from which we derive the fact, that Yavana-city was presumed to have a longitude west from Lanká, or the meridian of Ujjayiní, amounting to 60 degrees. The meridian over Yavana-city having a longitude of 30 degrees (consequently, east from Romaka-city), we arrive at the conclusion that by Yavana-pura is meant Alexandria. The error in determining the longitude of Rome from the meridian of Ujjayiní is conspicuous, but not so very astonishing, if we remember that even Ptolemy's estimates of longitudes exceed the truth. So, to take one instance, Kanogiza, or Kanoj, is made by him to have a longitude, east from the Insulæ Fortunatæ, of 145 degrees; the error amounting to nearly 50 degrees. The Hindu errors of position, carefully compared with the errors in the writings of Greek geographers, successively, would perhaps lead to important results for ascertaining the times of intercourse between Greek and Indian science. It is, however, not the object of the present paper to do this; and I fear I have already made too long a digression.

ADDITIONAL NOTE.

Since the reading of the foregoing paper, I have been enabled, by the kindness of Prof. Weber, to ascertain, that all the quotations of Utpala, with the exception of one half-stanza, occur in a MS. of the Berlin Library. In the colophon of that work the title is given as follows: "Ity Áryabhaṭa-siddhánta-vyákhyáne Bhaṭapradípe Daṣagíti-bháshyam samáptam." The concluding stanza is communicated in the Journ. Amer. Or. Soc., 6th Vol., p. 561, by Prof. Whitney, with the following translation: "Bhúta-Vishṇu (?) hath thus comprehensively explained—having learned it by the favour of his teacher—the Daṣagíti text-book (*Daṣagíti-sútram*), of very obscure meaning, formerly promulgated by Bhaṭṭa." It is evident that Utpala must have considered this Daṣagíti-bháshyam either as a composition by Áryabhaṭṭa himself, or as an authoritative paraphrase and substitute. It is somewhat puzzling that, at the end of the 3rd chapter of the Berlin MS., we find the words: "Iti ṣrímad-ácháryáryabhaṭavirachite siddhánta (r.-te) golapádaṣ chaturthaḥ." In the second chapter the author gives his own date: "shasṭyabdánáṃ shashṭir yadá vyatítás trayaṣ cha yugopádáḥ । adhiká vinṣati(r a)bdás tad iha mama janmato'títáḥ." The metre of the second half-stanza requires an emendation: perhaps we are to read *tadcha*, in lieu of *tad iha*. But still there remains a difficulty as to the meaning of *adhiká vinṣatir*. The stanza may mean: "When three of the four Ages, and 3,600 years, are past, then there are past more than twenty years[1] from my birth." If this be the sense, the date would be the year 478 from the beginning of the Christian era. Unfortunately, it is not clear whether the date of A'ryabhaṭṭa is meant, or that of Bhútavishṇu. However it may be, certain it is, that one stanza in the large extract which I have ascribed to Varáha-mihira, is to be found in the Daṣagíti-bháshyam, viz., उदयो यो लङ्कायां, &c. Hence this work must have been anterior to his time.

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[1] As a date requires precision, I should surmise that *adhiká* is a misread *tryadhiká;* the characters अ and त्र्य being liable to be confounded. The rendering, in this case, would be, "twenty-three years," and the date, A.D. 475.